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FOIL BEARING INVESTIGATION.(U)
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RR-77-02 NL

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DATE FILMED
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Prepared Under

Contract No. N00014-71-C-0001
OFFICE OF NAVAL RESEARCH
DEPARTMENT OF THE NAVY

Administered by

Scientific Officer
Mathematical and Information Sciences Division
Office of Naval Research
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Arlington, Virginia 22217
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FINAL REPORT

70 July 01 thru 76 Sept. 30

Research Sponsored by the OFFICE OF NAVAL RESEARCH
under
Contract N00014-71-C-0001 NR 062-297

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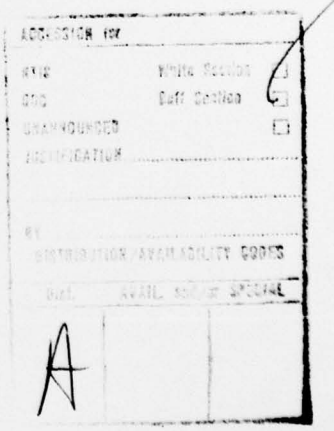

1.0 INTRODUCTION

1.1 Objectives

The general objective of efforts under this contract has been the development of fundamental understanding applicable to problems of current practical interest in the field of foil bearings.

1.2 Techniques

A major part of the effort has been of analytical nature. The high order problems encountered, have dictated mostly numerical methods of solution. A smaller but an important part of the work has been of experimental nature. Due to budgetary limitations, experimental work has been possible only where Ampex equipment could be utilized in the work.

1.3 Contributors

The work has been supervised by Mr. Wildmann and Mr. P. Szego and earlier by Dr. W. A. Gross.

Dr. A. Eshel has been the project engineer of the program. Messrs. M. Branger and A. R. Lowe contributed to the experimental parts of the work and discussions with Mr.F.K. Orcutt, Mr. A. F. Stahler, and Dr. L. Licht have provided useful inputs to the program.

1.4 Areas of Work

The areas in which accomplishments were made are summarized below.

1.4.1 General

A. Automation of programming for numerical solutions. By a related but independent effort, a precompiler was developed to solve automatically high order parabolic partial differential equations. This precompiler has been utilized to solve foil bearing problems.

B. High order accuracy numerical methods (Mehstellenverfahren). A computer program has been developed in FORMAC to obtain low band, high accuracy finite difference formulas in one dimension. Progress has been made in the multi-dimensional case but further work needs to be done.

C. Foil bearing design manual has been published. This is a compendium of work organized for easy reference.

1.4.2 Foil Bearing Application to Rotor Support

A. Slack in foils. Design data for controlling the slack in foil rotor supports has been generated.

B. The stiffness, film thickness and tension in loaded foil journal bearings have been studied. Reasonable correlations with Licht's experiments have been found.

1.4.3 Foil Bearing Applications in Magnetic Recording

A. Head to tape Separation in longitudinal recording. The effect of head corners was investigated theoretically in an earlier contract. Corresponding experimental work was carried out during the current project. The effect of pressure pads on film thickness has been established.

B. Head to tape separation in helical scan recording. The two dimensional flow around a high speed rotating head has been investigated.

C. Vacuum Columns. Dynamic and steady state behavior of tape in vacuum columns has been studied both theoretically and experimentally. Very good correlation has been found in the steady state cases.

D. Externally pressurized guides. The dynamic behavior has been established.

2.0 WORK DONE*

In the following, publications originating from this program are listed with a brief description.

2.1 General

2.1.1 A. Eshel, "On Fluid Inertia Effects in Infinitely Wide Foil Bearings", Trans. ASME, J. Lub. Tech, pp. 490-494, 1970.

2.1.2 A. Eshel and L. Licht, "Foil Bearing Design Manual", Ampex ONR Report RR 71-18, Sept. 1971. A compendium of results organized for ease of reference.

2.1.3 A. Eshel, "Transient Analysis of a Planar Hybrid Foil Bearing Model", ASME Trans., J. Lub. Tech., July 1974, pp. 432-436. Analysis of typical results of dynamic response in which both self-acting and external pressurization effects are present.

2.1.4 A. Eshel, "A Preprocessor for Automated Numerical Solution of Certain Lubrication Problems". Proceedings of the 7th International Gas Bearing Symposium. Cambridge, England, July 13-15, 1976, Paper D1.

2.2 Application to Rotor Support

2.2.1 A. Eshel, "Dynamic Analysis of Three-Foil Rotor Support System in Zero Gravity Environment", Trans. ASME, J. Lub. Tech., pp. 617-629, 1970.

*Most of the papers listed here are based on ONR reports. To avoid duplication, only one entry is made for each publication.

2.2.2 A. Eshel, "The Slack in a Stretched Thin Foil Bent against Two Parallel Cylinders", ASME Trans., J. Engrg. for Ind., August 1975, pp. 1149-1152.

2.2.3 A. Eshel, "Quasi Static Analysis of the Clearance and Stiffness of Foil Journal Bearings for a Brayton Cycle Turbo Alternator", ASME Trans., J. Lub Tech., July 1975, pp. 516-525.

The above publications deal with the theory of foil bearings for rotor support.

2.3 Applications to Magnetic Recording

2.3.1 A. Eshel and A. R. Lowe, "Experimental and Theoretical Investigation of Head to Tape Separation in Magnetic Recording", IEEE Trans. on Magnetics, Vol. MAG-9, Dec. 1973, pp. 683-688. Film thickness in the range of interest in magnetic recording is measured and compared to theoretical results.

2.3.2 A. Eshel, "Reduction of Air Films in Magnetic Recording by External Air Pressure", ASME Trans., J. Lub. Tech., April 1974, pp. 247-249. An effective means for reducing the air film thickness in magnetic recording is reported and analyzed.

2.3.3 A. Eshel, "Recent Progress in the Study of the Behavior of Tape in Vacuum Columns", Proc. Sixth International Gas Bearing Symposium, Southampton, England, March 27-29, 1974, pp. D4/51-58. Presents interim results in experimental work on vibration and contact of tape in vacuum columns.

2.3.4 A. Eshel, "Application of Foil Bearing Theory to Vacuum Columns", ASME Trans., J. Lub. Tech., July 1974, pp. 525-526. Analysis of a limiting case in which a flat uniformity zone exists in the vacuum column.

2.3.5 A. Eshel, "Analysis of the Contour of a Stationary Tape in a Vacuum Column," Int. J. Mech. Sci., 1976, pp. 17-22.

2.3.6 A. Eshel, "Flexible Wall Planar Flow Model for Tape Behavior in Vacuum Columns", ASME Trans., J. Lub. Tech., April 1976, pp. 344-348. Steady state analysis, experiments and comparison.

2.3.7 M. Wildmann, "Mechanical Limitations in Magnetic Recording", INTER MAG 1974, Paper No. 2.5.

3.0 FUTURE WORK

We are presently working in or contemplating work in the following areas.

3.1 General

A. Experimental work on externally pressurized foil bearings.

B. High order accuracy numerical methods for multidimensional problems.

C. Time may be ripe to revise the foil bearing design manual based on recent advances in the field.

3.2 *Foil Bearing Applications* to Rotor Support

A. Analysis of tensioned foil bearings with radial loads.

B. Analysis of new types of foil thrust bearings.

C. Analytical comparison of different types of foil bearings (tension, bending or compliant).

3.3 Foil Bearing Applications in Magnetic Recording

A. Further work on head to tape separation associated with high speed rotating heads. Possible study of dynamic effects in the tape ("bow waves").

B. Dynamics of tape in vacuum columns taking into account fluid inertia effects.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Unclassified
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): FOIL BEARING INVESTIGATION
5. TYPE OF REPORT & PERIOD COVERED: FINAL REPORT, 70 July 1 thru 76 Sept. 30
6. PERFORMING ORG. REPORT NUMBER: RR-77-02

7. AUTHOR(s): A. Eshel
8. CONTRACT OR GRANT NUMBER(s): N00014-71-C-001

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Ampex Corporation, Advanced Technology Division, 401 Broadway, Redwood City, California 94063
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: NR 062-297

11. CONTROLLING OFFICE NAME AND ADDRESS: Office of Naval Research, Department of the Navy (Code 613B:NM), 800 N. Quincy Street, Arlington, Virginia 22217
12. REPORT DATE: December 31, 1976
13. NUMBER OF PAGES: 8

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Final rept. 1 Jul 70 – 30 Sep 76
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report): 10p.

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Bearings
Foil Bearings
Lubrication
Vacuum Columns

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Foil bearing research performed at Ampex under ONR sponsorship is summarized. Theoretical and experimental effort has been carried out in three areas:

a) Development of analytical and experimental techniques applicable to foil bearings, as well as to other fields,
b) Application of foil bearings for support of high speed rotating machinery, and
c) Application of foil bearings in magnetic recording.

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